# Application Requirements for Operational Permits

Version 1.0 5/2015

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# Introduction

This document is intended to help make the content, arrangement, and submission of State Operational Stormwater applications more uniform. The contents of this document represent the Stormwater Program's preferred format for application organization and materials. Failure to adhere to the standards presented herein may delay application processing or result in rejection of an application altogether.

# Part 1. Application Submittal Guidance

All permit applications must be submitted on a CD/DVD by mail. Fee payments must be by check, payable to State of Vermont. Application submittals will not be accepted via email or through external ftp sites. Unless full scale paper copies of site plans are specifically requested by the Stormwater Program, electronic versions of site plans are preferred.

It is also encouraged that all correspondence on pending permit applications following the initial submittal of the application be conducted via email. This request applies to all regularly submitted stormwater permit applications and issued permits such as General Permit 3-9010, 3-9015, 3-9020, 3-9030, 3-9003, and all types of individual discharge permits. Correspondence with the Stormwater Program on issued permits should also be conducted electronically when possible as directed below in this section.

### 1.1 Application Format

A complete application is comprised of all the applicable application materials and a check for the applicable fees. These materials should be organized into 5 separate documents, saved individually as PDFs. The five PDFs should be named as shown below:

1. "NOI"
2. "Attachment 1: Narrative"
3. "Attachment 2: Worksheets"
4. "Attachment 3: Modeling"
5. "Attachment 4: Plans"

Each of the above referenced files should contain the following materials:

1. NOI:
    - A signed Notice of Intent. The most current version can be downloaded from the Stormwater Program website. The applicant and the application preparer should sign the form electronically before sending the final version. To sign the document, please use the adobe "Sign" tool to place a signature in the signature block. They may choose from the options under "Place Signature" to either "Type My Signature",

"Draw my Signature" or "Use an Image." If one has never signed electronically, further help can be found on the Adobe help site.

2. Attachment 1: Narrative
    - The project narrative- use narrative template
    - Location map- showing the outline of the site, the discharge point(s) and the location of the receiving water on a topographical map.
    - Soils map- either from the online soil survey or the soils may be overlaid on the existing conditions plan sheet.

3. Attachment 2: Worksheets
    - Schedule A(s)
    - All applicable STP worksheets
    - Applicable stormwater credit worksheets
    - Treatment standard waiver worksheets.
    - These should be organized by discharge point (i.e. Schedule A and all worksheets for DP #1, followed by Schedule A and all worksheets for DP #2, etc.). Include section breaks between discharge points.

4. Attachment 3: Modeling
    - Hydrologic modeling for all pertinent rainfall events. See the Modeling Guidance section of this document for specific instructions.

5. Attachment 4: Plans
    - Complete plan set including existing condition site plan, proposed condition site plan, and construction detail sheet for all proposed practices.

Also supply a check for all applicable fees. Checks should be made payable to the State of Vermont. Do not include a copy of the check on the CD/DVD.
Note: Please do not combine all of the application materials into a single file. Use the above format and naming convention.

A CD/DVD containing the complete application package can be sent to the following address:

DEC- Watershed Management Division
Stormwater Management Program
1 National Life Drive, Main 2
Montpelier, VT 05620-3522

**1.2 Permit Application Correspondence and Revisions**
Submission of permit-application related correspondence (e.g. response to technical review comments, plan changes, worksheet/form revisions) is requested via email following the initial submittal of the application.

If revisions to original application materials are requested by the Stormwater Program, it is expected that a complete attachment will be re-submitted with the response to comments. For example if the grass channel worksheet in Attachment 2 needs to be revised, then the entire Attachment 2 should be resubmitted and named as such “Attachment 2: Worksheets_revised_4-24-15”. In certain cases that involve large file sizes, the stormwater program may allow single sheets to be revised without re-submittal of the entire attachment. Your technical reviewer will direct you in this situation. Also, in the response to comments please indicate the location of any changes to the revised complete attachment (i.e. “grass channel worksheet inserted at p.10 of Attachment 2” or “Modeling revised for 1-yr storm event; p. 28-32 of Attachment 3”.)

**1.3 Correspondence for Issued Permits/Authorizations**
All forms, with the exception of the initial application form, such as Annual Inspection Reports, Restatements of Compliance and transfer forms, should be submitted electronically to: **anr.wsmdstormwatergeneral@state.vt.us**

All general correspondence related to a previously issued permit should be directed to the appropriate district technical staff member via email. A district staff directory can be found here: http://www.watershedmanagement.vt.gov/stormwater/htm/sw_districtcontacts_newcm.htm
All fees must be mailed to the address listed above with checks payable to the State of Vermont for the amount required.

Your assistance in paper-free permit applications is greatly appreciated. For additional stormwater permitting information, please visit the Stormwater Program website: http://www.watershedmanagement.vt.gov/stormwater.htm

# Part 2: Schedule A Guidance

The Schedule A form is a summary of the impervious surface distribution and means of treatment for each discharge point. A separate Schedule A is required for each discharge point. A **discharge point** is defined as the location where stormwater runoff form the site first encounters a “water of the state.” **Waters of the State** include, but are not limited to, streams (intermittent or perennial), rivers, lakes, ponds, reservoirs, and wetlands. The total impervious surface area proposed for coverage must match the total impervious surface area listed on the Schedule A(s), and match the total amount utilized for the permit fee calculation (and be reflective of amended totals as necessary for amendment applications). The **site** is defined as the area occupied by the impervious and disturbed pervious surfaces on the project.

When discharge points are located far from the site boundary, applicants may use points of interest (POI) as locations where compliance is demonstrated. A POI is a location where flow discharges from the site, but that can be well upslope of Waters of the State. In general, if compliance with the treatment standards is demonstrated at a site boundary POI, then compliance will be assumed at the actual discharge point.

### 2.1 Filling out the Schedule A when using Site Balancing

The Site Balancing Procedure can be used to meet treatment standards for a portion of the site by treating existing impervious in lieu of new development that cannot be treated due to site constraints. The Schedule A should always show the areas actually being treated. If existing impervious is being treated, that area should be displayed on the Schedule A. For example, if you are expanding impervious by 0.25 acres and site constraints prevent you from treating the expanded portion to current standards, then 0.25 acres of existing impervious that is being treated should appear on the Schedule A under existing impervious and the 0.25 acres of new impervious should not appear on the Schedule A. Please make a note on the Schedule A in the existing impervious box that this area is being used for site balancing (ie. 0.25 – treated via site balancing).

Often the area of existing impervious being treated via site balancing is slightly more than the new expanded portion that cannot be treated. In this case, include only the area of existing impervious on the Schedule A that is necessary to balance the area of new impervious. Keep in mind that the impervious on the Schedule A needs to match the NOI and that area will be used to calculate application and operating fees. However, please account for actual area being balanced in the sizing calculations and modeling.

Please make sure all the areas of new impervious, treated existing impervious, untreated existing impervious and redeveloped impervious are clearly identified on a site plan as well as in the narrative (a table with areas of each type of impervious is helpful). Also, note that when using the site balancing procedure an individual (INDS) permit must be sought. However, if the site is not within a stormwater impaired water, the permit may be renewed under General Permit 3-9010 rather than under an INDS permit.

## 2.2 Guidance on Terms

Receiving Water: The receiving water is the name of the waterbody that stormwater runoff from the site first enters. If the receiving water does not have a name, use the designation of "unnamed tributary to the X," where X is the first named waterbody. Please note that wetlands (no matter their classification) are considered Waters of the State. If the receiving water is a wetland, be specific as to the wetland's relationship to other Waters of the State. For instance: 1) Wetland tributary to X; or 2) Wetland draining into X. In situations where all of the stormwater is discharged to groundwater (infiltrated), the receiving water is "groundwater within the X watershed." In the instance that the site discharges to groundwater, but some overflow is expected via surface runoff into a Water of the State, the receiving water is "groundwater with overflow to X."

Latitude & Longitude of Discharge Point: This is the location in Degrees Minutes Seconds (DD° MM' SS.ss") format where the runoff from your site first enters a Water of the State for each discharge point.

Existing Impervious Surfaces: Do not include impervious on the Schedule A unless it has been treated in accordance with the Vermont Stormwater Management Manual, Volume I. Existing impervious surfaces treated via the site balancing procedure should be included on the Schedule A if site balancing is used.

Redevelopment: If you are redeveloping an area of impervious surface whose discharge is covered under an existing stormwater discharge permit (valid or expired) please contact the Stormwater Program to discuss whether or not coverage of this impervious surface is required under a new stormwater discharge permit or can be authorized under the existing permit. Please refer to Chapter 18 or Chapter 22 of the Environmental Protection Rules, for full definition of redevelopment.

## Part 3: STP Worksheet Guidance

Fill out one Schedule A for each discharge point. Following each Schedule A include the appropriate WQv Calculation Worksheet(s), Groundwater Recharge Calculation Worksheet, STP Worksheet(s), Stormwater Credit Worksheet(s) (if applicable), and Treatment Standard Waiver Worksheet(s) (if applicable). Groundwater recharge is a site wide standard, thus only one recharge worksheet is needed for the whole project.

Note that all questions on the worksheets refer to required elements in the Vermont Stormwater Management Manual, Vol. 1 and therefore must be addressed. An answer of "No" is subject to program approval and must be accompanied by a detailed explanation of why this element cannot be achieved onsite. Questions on STP worksheets should not be left blank.

Worksheets applicable to each discharge point should be bundled together with the corresponding Schedule A. The bundle for each discharge point should be saved as a single flat PDF called "**Attachment 2: Worksheets.**" The worksheet set for each discharge point should be organized in the following order:

1. Schedule A
2. $WQ_v$ Calculation Worksheet
3. Groundwater Recharge Calculation Worksheet or waiver (include only with applicable discharge points)
4. Treatment Standard Waiver Worksheet(s), if applicable
5. STP Worksheets
6. Stormwater Credit Worksheet(s), if applicable

All worksheets can be found here:
http://www.vtwaterquality.org/stormwater/htm/sw_appsformswkshts.htm

# Part 4: Runoff Modeling Guidance

This section provides guidance to make the review of operational stormwater applications more efficient. Below are several figures showing modeling outputs that have been underlined or circled in red indicating that these items should be highlighted on the modeling output summary sheets with the application to demonstrate compliance with each applicable treatment standard. If the project reports are printed directly to PDF the pertinent text can be highlighted in Adobe without printing a hard copy of the reports, thus this request can be met while maintaining the goal of paperless applications.

### 4.1 General Model Information

On the first subcatchment summary sheet for each storm event please highlight the following information:

- Runoff generation method (should be flow weighted (Weighted-Q), not area weighted (Weighted-CN))
- Unit hydrograph used
- Model time span
- Model time step
- Rainfall distribution type
- Rainfall amount

Runoff = 9.14 cfs @ 11.92 hrs, Volume= 0.432 af, Depth= 2.07"

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Type II 24-hr 1-yr Rainfall=2.30"

| Area (ac) | CN | Description |
|---|---|---|
| 2.500 | 98 | Paved parking, HSG B |
| 2.500 | | 100.00% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 1.0 | 50 | 0.0100 | 0.80 | | **Sheet Flow, sheet flow from lawn**<br>Smooth surfaces n= 0.011 P2= 2.50" |
| 0.4 | 50 | 0.0100 | 2.03 | | **Shallow Concentrated Flow, flow accross parking lot**<br>Paved Kv= 20.3 fps |
| 0.5 | 150 | 0.0100 | 4.60 | 73.55 | **Channel Flow, Grass Channel**<br>Area= 16.0 sf Perim= 28.5' r= 0.56'<br>n= 0.022 Earth, clean & straight |
| 1.9 | 250 | Total | | | |

**Figure 1: Subcatchment summary sheet showing the general model information that should be highlighted on the first subcatchment summary sheet for each rainfall event.**

## 4.2 Water Quality Treatment Standard

When modeling the Water Quality Storm (0.9”) with NRCS methods and treating with a flow based practice (grass channel), a modified CN must be used. On the subcatchment summary sheet for the Water Quality Storm please highlight the modified CN that was calculated using the Modified CN worksheet.

```
Runoff     =       3.00 cfs @   11.92 hrs,  Volume=        0.121 af,  Depth=  1.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-40.00 hrs, dt= 0.01 hrs
Type II 24-hr  1-yr Rainfall=2.30"

    Area (ac)    CN    Description
*       1.200    88    Modified CN
        1.200          100.00% Pervious Area

      Tc  Length    Slope  Velocity  Capacity  Description
   (min)    (feet)    (ft/ft)   (ft/sec)      (cfs)
```

**Figure 2: Subcatchment summary sheet for the Water Quality Storm showing the use of a Modified CN.**

## 4.3 Channel Protection Treatment Standard (CPv)

To demonstrate compliance with the Channel Protection Treatment Standard please highlight the Center of Mass detention time or the detention time provided by a 1” orifice on the pond summary sheet. The Center of Mass detention time should be as close to 720 minutes as possible for a 12 hour detention time or 1440 minutes if a 24 hour detention time is required. If using a 1” orifice refer to Part 4 of this document for additional guidance on demonstrating compliance with this standard.

Note that the model time span must be long enough so that the pond elevation returns to the permanent pool elevation for the 1-yr storm. This can be confirmed by verifying that the inflow and outflow volumes are the same.

Note that truncating the hydrograph by use of a short model time span will result in a shorter Center of Mass detention time and may incorrectly suggest the use of a 1” orifice.

```
Inflow Area =     1.000 ac,100.00% Impervious, Inflow Depth =  2.77"
Inflow      =     3.68 cfs @  12.01 hrs, Volume=       0.231 af
Outflow     =     0.11 cfs @  14.36 hrs, Volume=       0.231 af, Atten= 97%, Lag= 141.3 min
Primary     =     0.11 cfs @  14.36 hrs, Volume=       0.231 af

Routing by Stor-Ind method, Time Span= 0.00-140.00 hrs, dt= 0.05 hrs
Starting Elev= 6.75'  Surf.Area= 2,700 sf  Storage= 2,588 cf
Peak Elev= 8.41' @ 14.36 hrs  Surf.Area= 5,513 sf  Storage= 9,078 cf  (6,490 cf above start)

Plug-Flow detention time= 1,064.8 min calculated for 0.171 af (74% of inflow)
Center-of-Mass det. time= 727.7 min ( 1,485.3 - 757.6 )
```

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 5.00' | 12,800 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 5.00 | 0 | 0 | 0 |
| 6.00 | 1,800 | 900 | 900 |
| 7.00 | 3,000 | 2,400 | 3,300 |
| 8.00 | 4,500 | 3,750 | 7,050 |
| 9.00 | 7,000 | 5,750 | 12,800 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 6.75' | **1.8" Vert. Orifice/Grate** C= 0.600 |

**Primary OutFlow** Max=0.11 cfs @ 14.36 hrs HW=8.41' (Free Discharge)
└─**1=Orifice/Grate** (Orifice Controls 0.11 cfs @ 6.05 fps)

**Figure 3: Subcatchment summary sheet showing an appropriate model time span and center of mass detention time, verified by equivalent inflow and outflow volumes.**

## 4.4 Overbank Flood Protection Standard ($Q_p10$) and Extreme Flood Protection Standard ($Q_p100$)

Compliance with these standards is met by demonstrating that the routed post-development peak discharge rate does not exceed the pre-development peak flow rate for the 10-yr, 24-hr and 100-yr, 24-hr storms under the Type II rainfall distribution ($Q_p10_{post} \leq Q_p10_{pre}$ and $Q_p100_{post} \leq Q_p100_{pre}$). To demonstrate this in the modeling output, highlight the peak flow rate from the most downstream node in the pre-development/existing condition and the most downstream node in the proposed condition to show that the flow rate from the proposed condition is less than or equal to the existing condition. In the example below, the peak flow rate from node 5S would be compared to the peak flow rate from node 3P for demonstrating compliance with the $Q_p10$ and $Q_p100$ standards.

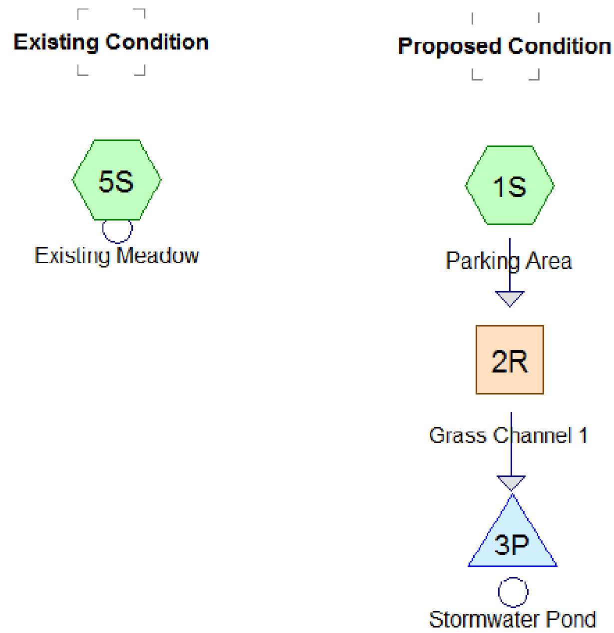



**Figure 5: Routing diagram for the Overbank Flood Protection and Extreme Flood Protection Standards example.**

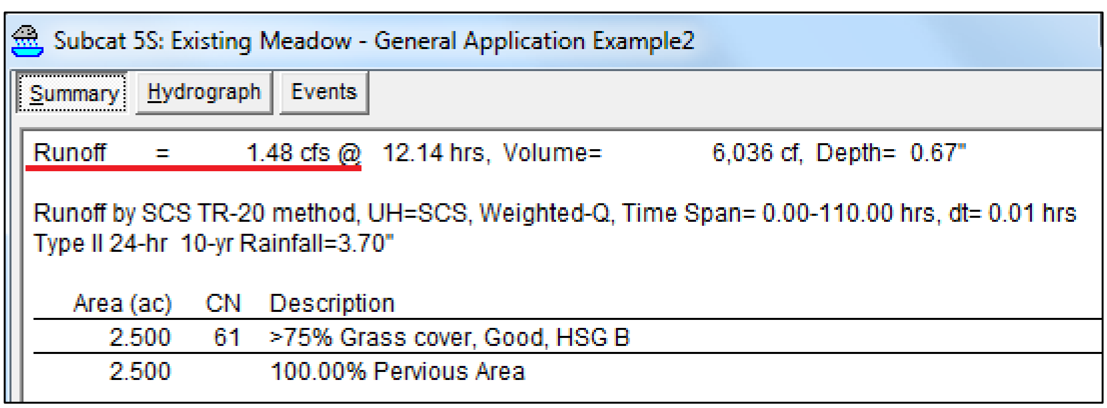



**Figure 6: Subcatchment summary sheet showing peak flow rate for the pre-development condition for node 5S.**

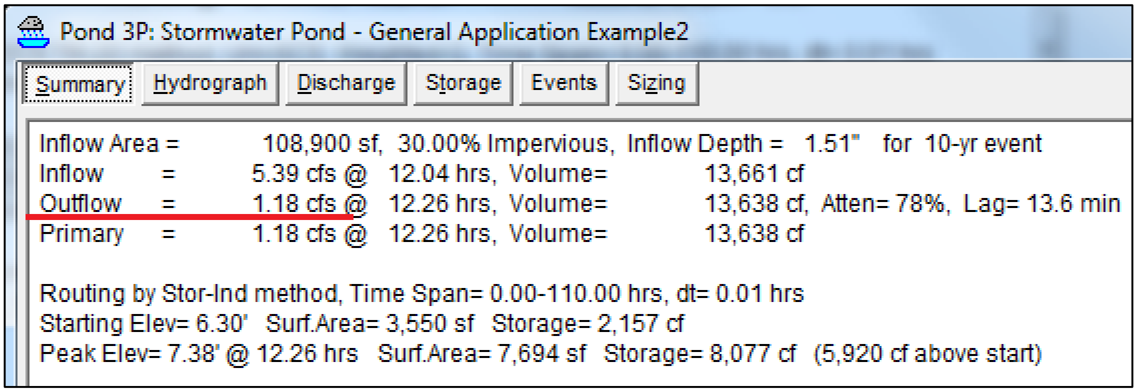



**Figure 7: Subcatchment summary sheet showing the peak flow rate for the proposed condition.**

Note that for ponds with multiple outflow designations (primary and secondary) the flows should be combined. For ponds with exfiltration specified as an outlet control (discarded flows) this flow will be considered in the total Outflow calculation, but does not need to be considered for compliance purposes with the $Q_p10$ and $Q_p100$ standards. In these cases, the total flow rate for compliance purposes is the outflow less the discarded flow.

In addition to demonstrating compliance with each treatment standard, conformance with the treatment practice requirements should also be demonstrated by highlighting pertinent information on the modeling summary sheets for the specific practice being used to meet the standards. If a “Required Element” in VSMM Vol. 1 is possible to demonstrate in the modeling, then it should be highlighted. This will facilitate the review of your application.

## 4.5 Ponds

The following Required Elements for Stormwater Ponds should be highlighted in the modeling output:

- 1-yr peak flow rate from the pond outlet
- Volume of the permanent pool
- Starting elevation (based on elevation of permanent pool and lowest outlet control)
- Outlet control structure type, size, and invert elevation (including barrel), consistent with the provided outlet control structure detail
- Outlet routing diagram demonstrating proper routing of the various outlet control structures through the riser barrel

Pond Summary Sheet:

```
Inflow Area =       119,790 sf,  36.36% Impervious,  Inflow Depth =  0.84"   for  1-yr event
Inflow     =      2.56 cfs @  12.15 hrs,  Volume=          8,415 cf
Outflow    =      0.23 cfs @  13.04 hrs,  Volume=          8,394 cf,  Atten= 91%,  Lag= 53.5 min
Primary    =      0.23 cfs @  13.04 hrs,  Volume=          8,394 cf
```

1-yr Peak Flow Rate

```
Routing by Stor-Ind method, Time Span= 0.00-110.00 hrs, dt= 0.01 hrs
Starting Elev= 6.30'   Surf.Area= 3,550 sf   Storage= 2,157 cf
Peak Elev= 7.21' @ 13.04 hrs   Surf.Area= 6,948 sf   Storage= 6,864 cf   (4,706 cf above start)

Plug-Flow detention time= 1,082.4 min calculated for 6,236 cf (74% of inflow)
Center-of-Mass det. time= 720.8 min ( 1,526.4 - 805.7 )
```

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 5.00' | 13,750 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 5.00 | 0 | 0 | 0 |
| 6.00 | 2,500 | 1,250 | 1,250 |
| 6.30 | 3,550 | 907 | 2,157 |
| 7.00 | 6,000 | 3,343 | 5,500 |
| 8.00 | 10,500 | 8,250 | 13,750 |

Volume of Permanent Pool

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5.00' | **12.0" Round Culvert** L= 50.0' Ke= 0.010<br>Inlet / Outlet Invert= 5.00' / 4.00' S= 0.0200 '/' Cc= 0.900<br>n= 0.025 Corrugated metal, Flow Area= 0.79 sf |
| #2 | Device 1 | 6.30' | **1.7" Vert. Orifice/Grate** C= 0.600 |
| #3 | Device 1 | 7.15' | **12.0" Horiz. Orifice/Grate** C= 0.600<br>Limited to weir flow at low heads |

Outlet Device Summary Table indicating outlets that conform with outlet control structure detail

```
Primary OutFlow  Max=0.22 cfs @ 13.04 hrs  HW=7.21'  (Free Discharge)
└─1=Culvert  (Passes 0.22 cfs of 3.59 cfs potential flow)
   ├─2=Orifice/Grate  (Orifice Controls 0.07 cfs @ 4.41 fps)
   └─3=Orifice/Grate  (Weir Controls 0.15 cfs @ 0.81 fps)
```

Outlet Routing Diagram- Outlet devices properly routed through riser barrel

**Figure 10: Pond summary sheet showing pertinent information that needs to be highlighted.**

### 4.5.1 Outlet Routing

The use of compound outlet structures is common for stormwater treatment practices. When modeling a compound outlet structure it is important to include not only the various outlet control structures on the riser, but also the riser barrel where flows from the individual outlet control devices combine before discharging to a stable conveyance or receiving body.

Designating an outlet device as Primary assumes free discharge for that device. In compound outlet structures (risers with multiple outlet control devices) this is often not a valid assumption, as the barrel can act to control flow rate even if the sum of individual outlet control devices could potentially pass more flow.

Proper outlet routing in a pond involves specifying the barrel as an outlet control device, designating it as the primary outflow, and then routing the other outlet control devices on the riser (orifices, weirs, overflow grates) through the barrel.  The easiest way to do this is to enter the barrel (as a culvert) as Device #1 in the "Outlet" table and then route the other devices through Device #1, as shown below:

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 5.00' | **12.0" Round Culvert** L= 50.0' Ke= 0.010<br>Inlet / Outlet Invert= 5.00' / 4.00' S= 0.0200 '/' Cc= 0.900<br>n= 0.025 Corrugated metal, Flow Area= 0.79 sf |
| #2 | Device 1 | 6.30' | **1.7" Vert. Orifice/Grate** C= 0.600 |
| #3 | Device 1 | 7.15' | **12.0" Horiz. Orifice/Grate** C= 0.600<br>Limited to weir flow at low heads |

**Primary OutFlow** Max=1.18 cfs @ 12.26 hrs HW=7.38' (Free Discharge)
**1=Culvert** (Passes 1.18 cfs of 3.72 cfs potential flow)
**2=Orifice/Grate** (Orifice Controls 0.08 cfs @ 4.83 fps)
**3=Orifice/Grate** (Weir Controls 1.11 cfs @ 1.56 fps)

**Figure 11: Pond outlet summary table and routing diagram showing inclusion of the barrel and proper routing of the other outlet control devices.**

This will ensure that flows are properly combined in the barrel and will allow for barrel control if necessary.  Note that the barrel should be modeled at the size specified in the outlet structure detail.

### 4.5.2 Pond Starting Elevation

Ponds with permanent pools must also include the elevation of the permanent pool in the modeling. This is done by specifying a pond starting elevation to ensure that the volume of the permanent pool is not counted toward the available storage volume of the pond.  The inflow and outflow volumes should be the same for a given rainfall event. If the outflow is significantly less than the inflow, this may indicate that the starting elevation has not been appropriately set. The starting elevation of the pond is established by the elevation of the lowest outlet control in the pond.  The pond summary sheet below illustrates a properly established starting elevation for a wet pond with a permanent pool.

Inflow Area = 2.000 ac, 0.00% Impervious, Inflow Depth = 4.16" for 100-yr event
Inflow = 13.41 cfs @ 11.98 hrs, Volume= 0.693 af
Outflow = 1.34 cfs @ 12.41 hrs, Volume= 0.693 af, Atten
Primary = 1.34 cfs @ 12.41 hrs, Volume= 0.693 af

**Inflow and outflow volumes are equivalent**

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs
Starting Elev= 814.00' Surf.Area= 3,000 sf Storage= 2,500 cf
Peak Elev= 816.14' @ 12.41 hrs Surf.Area= 12,830 sf Storage= 17,718 c

**Starting elevation listed between routing info and peak elevation**

Plug-Flow detention time= 277.2 min calculated for 0.635 af (92% of inflow
Center-of-Mass det. time= 201.0 min ( 990.5 - 789.4 )

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 812.00' | 31,000 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 812.00 | 0 | 0 | 0 |
| 813.00 | 1,000 | 500 | 500 |
| 814.00 | 3,000 | 2,000 | 2,500 |
| 815.00 | 6,000 | 4,500 | 7,000 |
| 816.00 | 12,000 | 9,000 | 16,000 |
| 817.00 | 18,000 | 15,000 | 31,000 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 812.00' | **12.0" Round Culvert** L= 50.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 812.00' / 811.50' S= 0.0100 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 0.79 sf |
| #2 | Device 1 | 814.00' | **3.0" Vert. Orifice/Grate** C= 0.600 |
| #3 | Device 1 | 815.00' | **6.0" Horiz. Orifice/Grate** C= 0.600 Limite |

**Starting elevation is determined by elevation of lowest outlet control**

**Primary OutFlow** Max=1.34 cfs @ 12.41 hrs HW=816.14' (Free Discharge)
└1=**Culvert** (Passes 1.34 cfs of 4.45 cfs potential flow)
├2=**Orifice/Grate** (Orifice Controls 0.34 cfs @ 6.83 fps)
└3=**Orifice/Grate** (Orifice Controls 1.01 cfs @ 5.14 fps)

**Figure 12: Pond summary sheet showing a properly established pond starting elevation to represent the permanent pool. Please highlight these items if using a pond with a permanent pool.**

Notice that the inflow and outflow volumes are equivalent, and that the starting elevation corresponds with the elevation of the lowest outlet control on the compound outlet structure.

### 4.6 Stormwater Wetlands

Stormwater Wetlands share many of the same required elements as Stormwater Ponds. Unless specified in the VSMM Vol. I, all of the pond criteria listed above also apply to Stormwater Wetlands including: conveyance criteria, outlet control device routing, forebay depths, and ponding depths for permanent pools. Refer to the above pond section 4.5.1 for a list of requirements that can be demonstrated in modeling output for Stormwater Wetlands. Note that the sizing requirements for Stormwater Wetlands are dependent on the specific design variant selected.

### 4.7 Infiltration Practices

The following required elements for infiltration practices should be highlighted in the modeling output:

- Exfiltration by constant velocity limited to 0.01 ft. above the floor of the practice OR by constant flow rate at all elevations by calculation from the infiltration rate and the bottom area of the practice (see example below).

Infiltration Example: Infiltration is typically modeled by selecting “Exfiltration” as the outlet control device and specifying “Discarded” as the routing option. Exfiltration can correctly be modeled using either a constant velocity (infiltration rate) over the surface area of the bottom of the practice or constant flow rate (product of infiltration rate and bottom area of practice). Both approaches are demonstrated below.

#### 4.7.1 Constant Velocity Infiltration

This approach involves entering the field verified infiltration rate into the model as the velocity term and limiting infiltration to a very small height (0.01 ft) above the bottom elevation of the practice. This will restrict infiltration to the bottom of the practice only, as required by VSMM Vol. I. If an infiltration basin has a bottom surface area of 2,000 sf, a bottom elevation of 2.00 ft. and an infiltration rate of 5.00 in/hr the correct way of setting this up would be as follows:

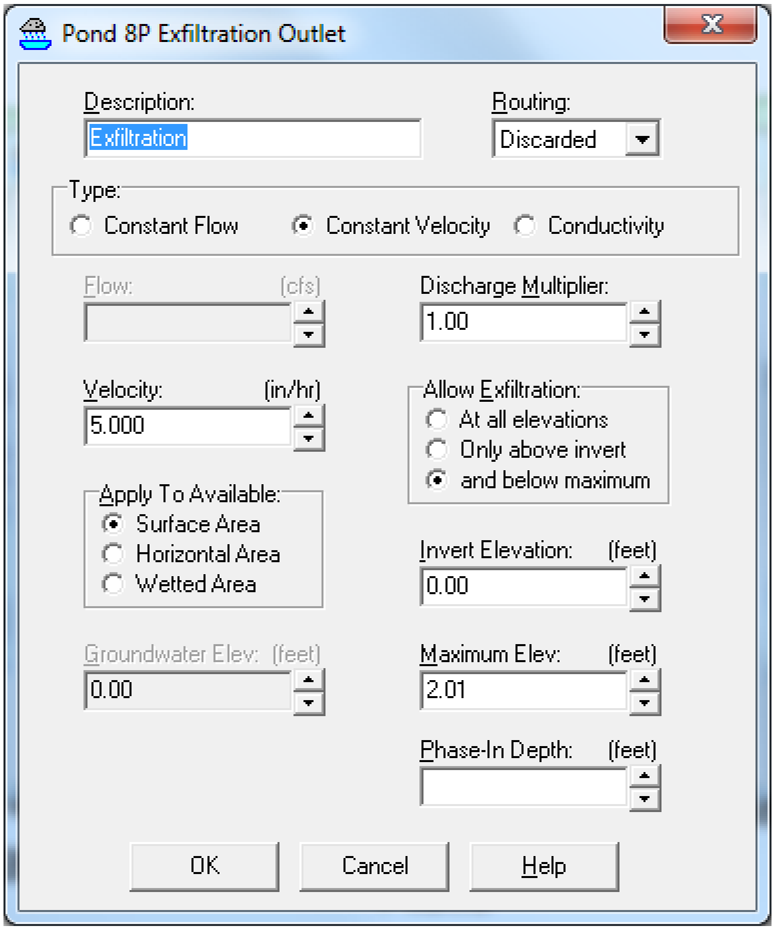



**Figure 13: Exfiltration screen showing constant velocity exfiltration.**

Note that although the bottom elevation of the basin is at 2.00 ft., the invert elevation is specified as 0.00 ft.  This is because the model treats the invert elevation as an impervious layer, through which there is no infiltration.  Because of this, the invert elevation specified on the infiltration screen must be less than the actual bottom elevation of the infiltration basin.  In effect it doesn't matter how much less; the invert elevation could be 1.99 ft. and the model will respond in the same manner as if it were 0.00 ft.

Specifying the invert elevation less than the bottom elevation of the basin allows for infiltration through the entire bottom surface area of the basin, and specifying the maximum exfiltration elevation as 0.01 ft. above the bottom elevation of the basin minimizes exfiltration through the side slopes of the basin, in accordance with VSMM Vol. 1.  The output summary for the example model is included below:

Inflow Area = 119,790 sf, 36.36% Impervious, Inflow Depth = 0.84" for 1-yr event
Inflow = 2.95 cfs @ 12.01 hrs, Volume= 8,415 cf
Outflow = 0.23 cfs @ 11.59 hrs, Volume= 8,415 cf, Atten= 92%, Lag= 0.0 min
Discarded = 0.23 cfs @ 11.59 hrs, Volume= 8,415 cf

Routing by Stor-Ind method, Time Span= 0.00-110.00 hrs, dt= 0.01 hrs
Peak Elev= 3.01' @ 12.72 hrs Surf.Area= 4,024 sf Storage= 3,048 cf

Plug-Flow detention time= 93.3 min calculated for 8,414 cf (100% of inflow)
Center-of-Mass det. time= 93.3 min ( 879.6 - 786.3 )

| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 2.00' | 15,000 cf | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet) |
|---|---|---|---|
| 2.00 | 2,000 | 0 | 0 |
| 3.00 | 4,000 | 3,000 | 3,000 |
| 4.00 | 6,000 | 5,000 | 8,000 |
| 5.00 | 8,000 | 7,000 | 15,000 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Discarded | 2.00' | **5.000 in/hr Exfiltration over Surface area below 2.01'** |

**Discarded OutFlow** Max=0.23 cfs @ 11.59 hrs HW=2.03' (Free Discharge)
↑**1=Exfiltration** (Exfiltration Controls 0.23 cfs)

**Figure 14: Pond summary sheet demonstrating constant velocity exfiltration. Items in red should be highlighted on the final output.**

### 4.7.2 Constant Flow Rate Infiltration

The other acceptable option is Constant Flow Rate Infiltration. With this method the field verified infiltration rate is multiplied by the surface area of the bottom of the practice to produce a volumetric flow rate. Through unit conversion the rate can be entered into the model in cfs and applied to all water surface elevations in the basin. This will produce a comparable result as the Constant Velocity Infiltration method. Using the previous example of a basin with a bottom area of 2,000 sf, a bottom elevation of 2.00 ft, and an infiltration rate of 5.00 in/hr the same result should be achieved:

$$Q = V \times A$$

$$Q = 5\frac{in}{hr} \times 2000\ ft^2 \times \frac{1\ ft}{12\ in} \times \frac{1\ hr}{3600\ s} = 0.23\ \frac{ft^3}{s}$$

The calculated flow rate can then be entered into the model using the Constant Flow Rate option as follows:

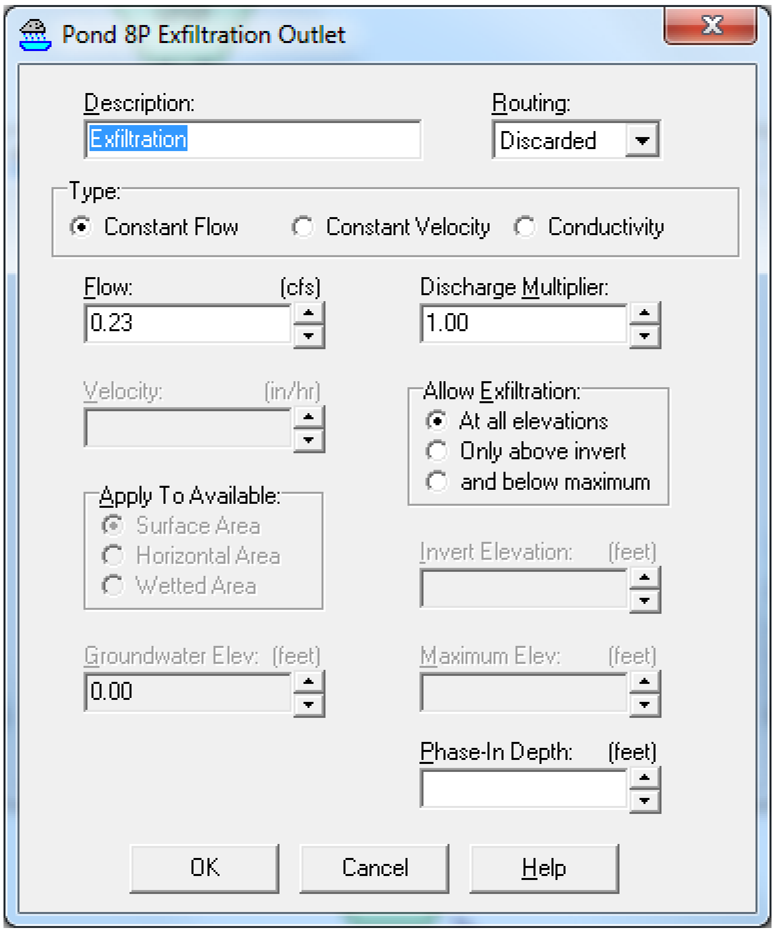



**Figure 15: Exfiltration screen showing constant flow rate exfiltration.**

Running the model with the calculated flow rate will yield an almost identical result to the Constant Velocity Infiltration method:

```
Inflow Area =        119,790 sf,  36.36% Impervious,  Inflow Depth =   0.84"    for  1-yr event
Inflow      =        2.95 cfs @   12.01 hrs,  Volume=            8,415 cf
Outflow     =        0.23 cfs @   11.57 hrs,  Volume=            8,415 cf,  Atten= 92%,  Lag= 0.0 min
Discarded =          0.23 cfs @   11.57 hrs,  Volume=            8,415 cf

Routing by Stor-Ind method, Time Span= 0.00-110.00 hrs, dt= 0.01 hrs
Peak Elev= 3.02' @ 12.75 hrs   Surf.Area= 4,032 sf   Storage= 3,065 cf

Plug-Flow detention time= 96.0 min calculated for 8,414 cf (100% of inflow)
Center-of-Mass det. time= 95.9 min ( 882.3 - 786.3 )

Volume        Invert      Avail.Storage    Storage Description
  #1            2.00'         15,000 cf    Custom Stage Data (Prismatic) Listed below (Recalc)

 Elevation          Surf.Area         Inc.Store        Cum.Store
    (feet)            (sq-ft)       (cubic-feet)     (cubic-feet)
      2.00              2,000                  0                0
      3.00              4,000              3,000            3,000
      4.00              6,000              5,000            8,000
      5.00              8,000              7,000           15,000

Device    Routing            Invert    Outlet Devices
  #1      Discarded            2.00'   0.23 cfs Exfiltration at all elevations

Discarded OutFlow  Max=0.23 cfs @ 11.57 hrs  HW=2.03'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 0.23 cfs)
```

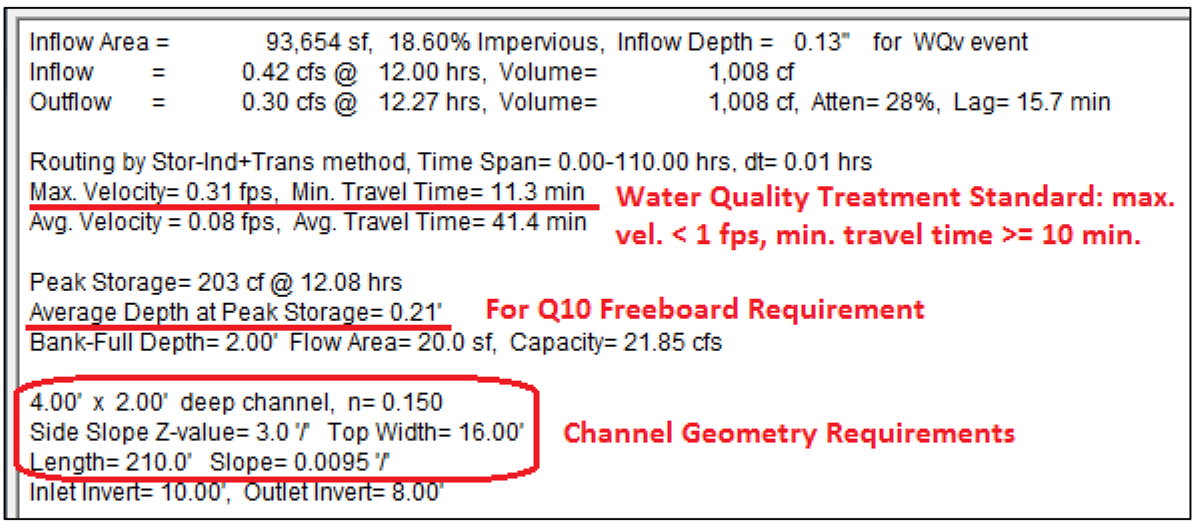
**Figure 16: Pond summary sheet showing constant flow rate exfiltration. Compare to Figure 14. Items in red should be highlighted on the final output.**

## 4.8 Open Channel Systems

The following Required Elements for Open Channel Systems should be highlighted in the modeling output:

- Peak velocity associated with the Water Quality Storm and the 1-yr storm. Must be < 1 fps for the Water Quality Storm and non-erosive for the 1-yr storm.
- Minimum Travel Time (residence time) for the Water Quality Storm
- Channel Geometry (length, bottom width, side slopes)
- Flow Depth
- Manning's Number (varied with depth for different storm events)
- Longitudinal Slope (< 4%)
- Freeboard during 10-yr storm (must be at least 6" during peak depth)

An example for grass channels is included below:



Inflow Area = 93,654 sf, 18.60% Impervious, Inflow Depth = 0.13" for WQv event
Inflow = 0.42 cfs @ 12.00 hrs, Volume= 1,008 cf
Outflow = 0.30 cfs @ 12.27 hrs, Volume= 1,008 cf, Atten= 28%, Lag= 15.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-110.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.31 fps, Min. Travel Time= 11.3 min
Avg. Velocity = 0.08 fps, Avg. Travel Time= 41.4 min

Peak Storage= 203 cf @ 12.08 hrs
Average Depth at Peak Storage= 0.21'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 21.85 cfs

4.00' x 2.00' deep channel, n= 0.150
Side Slope Z-value= 3.0 '/' Top Width= 16.00'
Length= 210.0' Slope= 0.0095 '/'
Inlet Invert= 10.00', Outlet Invert= 8.00'



**Figure 17: Reach summary sheet showing the conformance with the required elements of a grass channel. Items in red should be highlighted on the final output.**

# Part 5: Channel Protection Storage Volume Estimation Methods

The Channel Protection Treatment Standard is met by providing either 12 or 24 hours of extended detention storage for the Type II, 1-yr, 24-hr rainfall event. The standard can be met using one of the following methods.

### 5.1 Center of Mass Detention Time

To comply with the Channel Protection Treatment Standard, demonstrate that the center of mass detention time is equal to the required 12 or 24 hours of extended detention as dictated by the fisheries habitat designation for the receiving water body.

a. Many computer aided hydrologic models will calculate the center of mass detention time. This is the Stormwater Program's preferred method of verification of detention time.

b. If a pond is used as treatment the calculated center of mass detention time in the pond during the 1-year, 24-hour design storm shall be as close to 12 hrs. (720 min.) or 24 hrs. (1440 min.) as possible.

c. Remember to make sure that the outflow hydrograph represents 100% of the inflow by ensuring that your calculation time span is long enough. Otherwise, the center of mass detention time reported by the software may not be correct. Most programs have a default calculation time span that is too short to capture the end of the outflow when a pond has such long detention times. Additionally, ensure that if you have a permanent pool in your pond, that the storage encoded into your model only encompasses the storage above the permanent pool.

d. The minimum orifice size is 1 inch; designers will not be required to demonstrate more detention time than a 1 inch orifice can provide. However, to maximize the detention time provided by the 1 inch orifice, the pond should have the available storage to contain the CPv between the 1 inch orifice and the next highest outlet control (i.e there should be no discharge through the next highest outlet control for the 1-year storm.)

For reporting purposes, the channel protection volume (CPv) is the peak storage ($V_s$) produced by this low flow orifice that provides the maximum required detention. The average release rate is then equal to $V_s$ divided by the number of hours of extended detention.

### 5.2 Harrington Method

If computer aided hydrologic modeling is not available, use the Harrington Method provided in Sec. 1.3.1 of the 2002 VSMM to determine the required storage volume.

a. Note that because this method requires the use of the time of concentration ($T_c$), using the Harrington Method is only appropriate if the area draining to the channel protection practice is a single homogeneous subwatershed. Typically if designers are dealing with more than one subwatershed, or a subwatershed with multiple land covers, draining to a practice, they are using a computer aided model and thus should use the method outlined above~~.~~ (free sample versions of modeling software can be downloaded from the internet).

b. If the Harrington Method is used, the following information must be included:

i. Calculations (including all variables) of the CPv (i.e. $T_c$, $q_u$, Vs, CN, etc.).

ii. Calculation of the required orifice size (including all variables).

iii. Demonstration that the calculated orifice size was used in the outlet structure and/or that the peak storage volume in the pond is equivalent to the required storage CPv.

iv. Note that the minimum $T_c$ for use with Harrington Method is 0.1 hrs. (6 min.).

For example calculations, refer to Volume II of the VSMM, Appendix C1.

## Part 6: Plan Sheet Guidance

Site plans and maps shall be drawn at an appropriate scale to clearly depict stormwater management design and details. Plans should be in a single separate pdf called “Attachment 4: Plans”. They should be in the following order: Existing condition, proposed condition, construction details.

All plan sheets must include:

1. Legend
2. Scale bar
3. North arrow
4. Site boundary
5. Labeled discharge points
6. Labeled locations of STPs/Credits
7. Subcatchment boundaries and labels that correspond with subcatchment/reach/pond names in the runoff modeling
8. Delineation of impervious types including new impervious, treated existing impervious, untreated existing impervious and redeveloped impervious
9. Time of concentration flow-paths for each subcatchment
10. Current revision dates

- **Existing conditions site plan**: Depict all existing features and existing condition subwatershed delineations and time of concentration paths utilized in modeling, and shall depict POIs/discharge points. This plan sheet may include an overlay of the soil series and HSG soils.

- **Proposed conditions site plans**: Identify existing impervious, redeveloped impervious and new (expanded) impervious clearly in the legend. Label Discharge Points (and POIs) and all STPs and design credits that are utilized for treatment. Proposed conditions plans shall also depict post-development subwatershed delineations and time of concentration flow paths utilized in modeling, and shall depict POIs/discharge points. Indicate access points for maintenance of STPs. Multiple plan sheets may be necessary to provide the required information

- **Detail sheet:** Include all applicable STPs for the project demonstrating adherence to the required design criteria including; pond cross sections, outlet structures with orifice placement, barrel dimension, and all applicable credit design details. Also include typical details when and where credits requiring specific criteria will be utilized to meet applicable treatment standards. The detail sheet shall also include construction notes regarding phasing and routing of stormwater to sensitive practices such as infiltration practices prior to their completion.

- Other plan sheets may be included if they are applicable to stormwater management.

# Part 7: Sediment Offset Calculation Guidance

This guidance is offered in addition to Appendix B of Chapter 22: Stormwater Management Rule for Stormwater Impaired Waters. New development within stormwater impaired watersheds generally will require a sediment offset.  The individual discharge permits in conjunction with permitted offset projects in impaired watersheds will result in the statutorily established net-zero discharge to receiving waters. Net-zero discharge can be established through on-site treatment, an on-site or off-site offset project or through payment of a stormwater impact fee, as stated in Appendix B of Chapter 22. If your project falls within the watershed of one of the Stormwater Impaired Waters listed on the 303(d) list, please contact your District Analyst to determine if an offset is necessary.

If all runoff from the site can be infiltrated into the ground up to the 1 year storm, no offset will be required. If any runoff will be produced from the proposed development, an offset will be required for the whole project. Guidance on the calculation of sediment loading for pre and post development conditions is provided below.

### 7.1 Simple Method Calculations

The Simple Method is used to estimate sediment loading from stormwater runoff for urban and developing areas. Results of the sediment loading calculations show the net increase or decrease in sediment loading over pre-development conditions and are used to represent the total loading that must be offset.

It is best to create a spreadsheet showing each of the parameters and values used to calculate the simple method loading calculation. Specify each land use type and the C value you chose to represent that use. Be sure to include a reference for where the C value was obtained and a reference for where the annual runoff was obtained. To the extent possible, specify uniform land use areas with individual C values as they will generate more accurate loading calculations. For example, identify the amount of parking, roads, lawns and rooftop along with their individual C values rather than using one C value for commercial or residential development. Include in the calculations what value of margin of safety was used.

Chapter 8 of the New Hampshire Stormwater Manual provides a good technical reference for sediment loading calculations.
http://des.nh.gov/organization/divisions/water/stormwater/documents/wd-08-20a_ch8.pdf. This provides background on the simple method calculations and how they should be used in estimating sediment loads from pre and post development conditions.

The final simple method calculations should show the difference between the pre and post development loading as well as call out the margin of safety used. Write a short summary of your findings in the Narrative document under a new heading called Sediment Offset Calculations. After calculating pre and post development loads, please include the following information on a sediment offset calculation sheet:

- Predevelopment load: _____lbs.
- Post Development load: _____lbs.
- Post Development load after treatment (80% reduction if meeting all standards):_____lbs.
- Margin of Safety ____ %
- Increase in loading: ____ lbs.
- Percent increase: _____%

If runoff from the site can be infiltrated into the ground up to the 1 year storm, that portion of the site can assume 100% reduction in sediment loading rather than 80% for other types of treatment practices.

**7.2 Offset fee calculations**

If you choose to meet the offset requirement by paying an offset fee rather than providing an on-site or off-site offset project, you must first check with your district analyst to make sure that there is available offset capacity within the same stormwater impaired water as your project. Many impaired watersheds have already established standalone offset projects that can be "bought into". If there is available capacity in that watershed to buy into, and the project design meets all of the current standards outlined in the VSMM (Water Quality, Recharge and Channel Protection), payment of sediment offset fees may be calculated as follows:

**Area** of proposed impervious in acres x **$6,000** per acre = $ total offset fee

This calculation must be included in the Narrative. The applicant may wait to submit the offset fee check until technical review is complete, however the offset check must be received before a permit can be issued.